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Thought Systems and Network Centric Warfare

Martin Burke

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and
Network Centric Warfare

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ABSTRACT

The notion of Thought Warfare and Anti-Warfare (TWAW) has been introduced in earlier work as a way of thinking about future military conflict and its avoidance. TWAW involves the dynamic interaction of allies' and adversaries' Thought Systems. Current Thought Systems involve entities capable of cognition, emotion and volition - typically (groups of) people - interacting via networks of information and data systems.

This paper summarises a conceptualisation, ie a system of ideas, of the domain of Thought Systems. The relationship between TWAW and Network Centric Warfare (NCW) is explained: TWAW encompasses NCW. Unlike NCW, TWAW explicitly considers the interaction of will and feelings as well as knowledge, information and data in networked systems of people and machines in both the conduct of war and in the maintenance of peace. This affords various new insights that may be of significance to the NCW community.

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Thought System and Network Centric Warfare

Executive Summary

In *Thinking Together*, [Burke, DSTO-RR-0173, 2000], the notion of **Thought Warfare and Anti-Warfare (TWAW)** is introduced as a way of thinking about military conflict and its avoidance; it is foreseen as an increasingly important Defence issue in the twenty-first century. TWAW involves the dynamic interaction of allies' and adversaries' **Thought Systems**. Current Thought Systems involve entities capable of cognition, emotion and volition - typically (groups of) people - interacting via networks of information and data systems.

This paper summarises the conceptualisation, ie the system of ideas, of the domain of Thought Systems presented in *Thinking Together*. Simple architectural techniques are used to assist the reader to develop an understanding of the distinguishing features of the concepts involved that is sufficient to grasp the nature of the arguments relating to Thought Systems and TWAW developed elsewhere. Illustrative examples are outlined to indicate how the conceptualisation can be applied in this respect.

The major features of the conceptualisation are:

- **Thought Systems** are considered to consist of five principal types of components namely: **Data Systems**, **Information Systems**, **Knowledge Systems**, **Will Systems** and **Feeling Systems**. Figures 1 and 2 and Table 1 depict their inter-relationship. The goal in synthesising Thought Systems is to achieve synergy in the sense that the "capability" of a Thought System is greater than the sum of the capabilities of its component Data Systems, Information Systems, Knowledge Systems, Will Systems and Feeling Systems.
- **Meaning** is the most important issue in the domain; the conceptualisation is dominated by what is involved in assigning, deriving and sharing meaning by Information Systems, Knowledge Systems, Thought Systems, etc.
- Recursive relationships of intelligence/computing, cognition/knowing, consciousness/thinking, etc give rise to **hierarchies of levels of complexity** in Information Systems, Knowledge Systems, Thought Systems, etc.
- Some of the concepts are **extensively inter-related**. For example, the concept of schema is inter-woven throughout the conceptualisation.

It is emphasised that the conceptualisation does not commit to a "mind as machine" metaphor in which cognition and thought are considered to be merely information processing activities. It adopts a radically different stance: it assumes that "**meaning matters**".

The paper explains the relationship between TWAW and Network Centric Warfare (NCW): **TWAW encompasses NCW**. Unlike NCW, TWAW explicitly considers the interaction of will and feelings as well as knowledge, information and data in networked systems of people and machines in both the conduct of war and in the maintenance of peace. This affords various new insights that may be of significance to the NCW community. For example:

- It exposes the natures of various **concepts** (and their **inter-relationships**) that are of crucial importance in NCW. These include:
  - system;
  - architecture;
  - culture/Culture System;
  - understanding;
  - meaning;
  - thought/Thought System;
  - knowledge/Knowledge System;
  - feeling/Feeling System;
  - will/Will System;
  - information/Information System;
  - data/Data System.
- It provides a **coherent way of thinking**, and a **language** to support discourse, about current military issues of relevance to the NCW community.
- It promotes **speculation** about the nature of future military conflict and its avoidance related to NCW. In particular, it promotes speculation about **new forms of Thought System** that may provide significant comparative advantage in this respect.

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At other stages of his career, Martin has held research and management positions in ITD's Information Architectures Group, ITD's Software Systems Engineering Group, the UK Atomic Energy Authority, the SEMA Group Research Centre and Rolls Royce (Aero).

Martin has a BSc (Hons) in Physics, a MSc in Mathematical Statistics and a PhD in Engineering Mathematics.

Contents

1. Introduction

1.1 Context

This report is an output of a research effort initiated within the Joint Systems Branch of DSTO. It has been carried out as part of DSTO Task JNT 99/018 (Architecture Support and Technology). Dr Michael Jarvis of the Capability Analysis Staff has been the primary point of contact in Australian Defence Headquarters for the work.

1.2 Readership

The paper has been written to be read by members of the Defence community particularly those concerned with "alternate futures" and long-term strategic planning. It assumes that the reader is familiar with concepts such as the Revolution in Military Affairs, (RMA), Knowledge Warfare, C4ISREW, etc. No particular academic background has been assumed of its readership. All arguments developed in the paper are couched in terms of concepts that are introduced in the paper. Wherever possible, "plain English" is used.

1.3 Background and Motivation

1.3.1 War and Anti-War

Toffler and Toffler have introduced the notion of War and Anti-War as a new way of thinking[1] about military conflict and its avoidance, [Toffler and Toffler 1993]. Their basic premises are that, in any epoch:

- the way that wealth is created strongly influences the way that war is made;
- different forms of warfighting require different forms of peacekeeping.

They contend that, broadly speaking, history can be divided into two epochs dominated by distinctly different forms of wealth creation and warfighting: an Agrarian Age characterised by the hoe and the sword; and an Industrial Age characterised by mass production and mass destruction. They argue that, as information and knowledge become the core of advanced economies, the transition into a third epoch, the Information (or Knowledge) Age, will occur. They forecast that information and knowledge strategies will increasingly dominate in business, warfighting and peacekeeping. They speculate on many issues including:

- the use of artificial forms of intelligence in military decision making;
- the use of precision genetic weaponry in attacking specific ethnic or racial groups;
- the use of virtual reality weapons in confusing enemies;
- the use of electronic "ants" in penetrating business and military computer systems;
- the use of digital media as an alternative to traditional means of diplomacy;
- the emergence of "Peace corporations" that profit by maintaining peace in assigned regions;
- the re-structuring of the United Nations to give various sorts of communities greater roles in "peace-fare".

[1] Thomas Kuhn, [Kuhn 1996 (1962)], coined the term "paradigm shift" to refer to such changes in thinking.

1.3.2 Thinking Systems/Knowledge Warfare and Anti-Warfare

The Tofflers' foresee that advances in information and telecommunications technologies will lead to Knowledge Warfare and Anti-Warfare (KWAW) being the pre-eminent Defence issue in the twenty-first century[2]. They introduced the idea of Thinking Systems as entities in which groups of people act as knowledge agents supported by networks of information and data systems. They discussed how KWAW concerns the interaction of allies' and adversaries' Thinking Systems.

The Zapatista "social netwar" in Mexico is a seminal case of KWAW. According to Ronfeldt et al, [Ronfeldt, Arquilla et al. 1998], the social netwar started in 1994 as a result of the guerilla-like insurgency of the Zapatista National Liberation Army (EZLN) against the Mexican government. The EZLN's small indigenous force started a violent insurrection in Chiapas, an isolated region of southern Mexico. They then declared war on the Mexican government, vowed to march on Mexico City, proclaimed a revolutionary agenda, began an international media campaign for sympathy and support, and invited foreign observers and monitors to come to Chiapas. The government's response was to order the army and police to suppress the insurrection and to downplay its size, scope and causes. This combination of events aroused a multitude of activists associated with a variety of non-governmental organisations (NGOs) from around the world to "swarm" electronically and physically. They linked up with Mexican NGOs to voice solidarity with the EZLN's demands and to press for non-violent change. The protagonists communicated, coordinated and conducted their campaign in an "internetted" manner and without a central command. Within a fortnight, Mexico's president called a halt to combat operations and agreed to enter negotiations including consideration of major democratic reforms. Over the next few years, a social netwar raged which, with very few violent side-effects, had profound repercussions for the Mexican political system. It was the first example of social netwar; its full implications for the future of KWAW have yet to be realised.

1.3.3 Network Centric Warfare

KWAW is considered to be a "bigger" concept than that of Network Centric Warfare (NCW). NCW is defined by Alberts et al, [Alberts, Garstka et al. 1999], p2, as:

> *'an information superiority-enabled concept of operation that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. In essence, NCW translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace.'*

As they explain, [Alberts, Garstka et al. 1999], p6:

> *'... the power of NCW is derived from the effective linking or networking of knowledgeable entities that are geographically or hierarchically dispersed. The networking of*

[2] Subsequent developments strongly suggest that this prediction is likely to be realised. For example, Australian Strategic Policy, [Defence 1997], identifies the "Knowledge Edge" as Australia's highest Defence priority and Joint Vision 2010, [DOD 1997] stresses the importance of "Information Superiority" in future warfighting involving the US Armed Forces.

knowledgeable entities enables them to share information and collaborate to develop shared awareness, and also to collaborate with one another to achieve a degree of self-synchronisation.'

The scope of NCW is considered to be, broadly speaking, the same as what the Tofflers' mean by the term "Knowledge Warfare". NCW does not, however, explicitly consider "Knowledge Anti-Warfare".

1.3.4 Thought Systems/Thought Warfare and Anti-Warfare

The current work has been motivated by the perception that the Tofflers' thinking, despite having identified and scoped an important domain, lacks coherence in some important respects. For example, it was judged that it would be difficult to provide a cogent description of the Zapatista social netwar using just the concepts introduced in the Tofflers' book. Furthermore, since the Zapatista social netwar was primarily an Anti-Warfare issue, neither could it be addressed adequately by just the concepts set out by Alberts et al, [Alberts, Garstka et al. 1999]. The following were considered to be important deficiencies in the Tofflers' thinking:

- failure to distinguish between the data, information, knowledge[3], will and feeling aspects of Thinking Systems and KWAW;
- failure to capture the nature of the inter-relationships of the data, information, knowledge, will and feeling aspects of Thinking Systems and KWAW.

It was considered likely that using an architectural approach to re-conceptualise the domain would afford a more coherent insight into the nature of the domain. Within this approach, Thought Systems (TS) are proposed as being broadly equivalent to the Tofflers' Thinking Systems. Thought Systems are considered to consist of five principal types of components namely: Data Systems (DS), Information Systems (IS), Knowledge Systems (KS), Will Systems (WS) and Feeling Systems (FS). Furthermore, the term Knowledge Warfare and Anti-Warfare is seen to be a misleadingly narrow term for the domain to which it refers. The term Thought Warfare and Anti-Warfare (TWAW) is regarded as being more appropriate since it captures not just the cognitive aspects of the domain but also the emotional and volitional aspects.

It was speculated that a coherent conceptualisation[4] of the TWAW domain would be valuable in various ways in the Defence context. For example, observation of recent Australian Defence initiatives such as the Defence Information Environment (DIE), [Chin 1999], [Burns 2000]; Takari, [Chessell 1997], [Takari 2000]; and Project Sphinx, [DFW 1999] suggests that:

- current Australian Defence capability development focuses on Data Systems and Information Systems;
- very little explicit thought and action is devoted to Knowledge Systems, Will Systems or Feeling Systems;
- the goal of achieving synergy through their interaction is largely overlooked.

Such initiatives appear to suffer from the lack a "big picture" that encompasses all of the important issues of TWAW. This suggests that a coherent conceptualisation of the TWAW domain would be a valuable immediate contribution to those involved with

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[3] In an earlier work, [Toffler 1990], Toffler uses the words "data", "information", and "knowledge" interchangeably "to avoid tedious repetition"!

[4] In this work, the term "conceptualisation" is used to refer to "a system of ideas".

such initiatives and may also afford various new insights that are of significance to Network Centric Warfare. This in turn could be expected to promote the generation of further original ideas that could also be exploited in the Defence context.

In summary, the prospect is that the conceptualisation of the TWAW domain may provoke changes in thinking in the Defence community that are better suited to the development of Defence capability in an epoch of TWAW than those that prevail currently.

1.4 Scope and Objectives

The primary objective of the research presented in *Thinking Together* was:

- to contribute to a Revolution in Military Affairs, (RMA), [ORMA 1999], by proposing new ways of thinking that may influence future military conflicts and their avoidance.

Secondary objectives derived from this were:

- to introduce the notion of Thought Warfare and Anti-Warfare (TWAW) as a generalisation of Knowledge Warfare and Anti-Warfare [Toffler and Toffler 1993].
- to begin the development of a coherent conceptualisation of the domain of TWAW;
- to propose new forms of Thought System that could provide significant comparative advantage in TWAW.

The objective of this paper is:

- to use plain English and simple architectural techniques to introduce the conceptualisation of the domain of Thought Systems developed in *Thinking Together.*

The intentions are:

- to assist the reader to develop an understanding of the distinguishing features of the concepts involved that is sufficient to grasp the nature of the arguments relating to Thought Systems, TWAW and NCW developed elsewhere;
- to afford new insights that are of significance to NCW;
- to promote discourse in the Defence community regarding its contents.

1.5 Approach

The approach adopted in pursuing the objectives has been strongly influenced by the following factors;

- the scope of the subject domain is enormously large and diverse;
- no single academic discipline "spans" the whole domain[5];
- the paper's primary audience will prefer that its ideas can be easily grasped and that they are expressed in non-technical terms;
- the paper's author is not expert in several important aspects of the domain.

Accordingly, the approach adopted has been one of creative but systematic multi-disciplinary thinking based upon a simple understanding of a relatively small number

[5] Furthermore, the domain does not fall entirely within the boundaries of empirical science.

(approximately 35) of central concepts. The approach has been guided by Kline's *Conceptual Foundations for Multi-Disciplinary Thinking*, [Kline 1995], but does not comply with it in all respects. The approach uses architectural methods to deal with systems issues following the principles expounded by Burke in *Understanding Architecture*, [Burke 2000].

The approach aims to provide a crude but coherent conceptualisation of the subject domain that is adequate for preliminary (and suitably qualified) explanatory and predictive purposes and facilitates the proposal of new hypotheses. The basic intention is to give an impression of an emerging and rapidly changing subject that allows its major features to be distinguished and the nature of the change to be appreciated.[6]

It is emphasised that, since the paper's subject domain is fundamentally multi-disciplinary in nature, the approach does not attempt to comply with the conventions of any single discipline. Bearing this in mind, the approach aims to be academically sound; it does not, however, aspire to be scholastically rigorous. As a matter of practical necessity, there are many aspects of the work that have been conjectured, invented or devised without the benefit of any prior knowledge other than that can be acquired by everyday experience or by reference to readily accessible texts. For example, no attempt has been made, in the first instance, to survey and review the extensive literature that relates to the concepts of cognition, consciousness etc. Instead, the "vulgar" and longstanding understandings of these concepts reflected by their definitions in the *Oxford English Dictionary*, [Sykes 1977], have been preferred initially. In subsequent refinements of this work, it may be appropriate to revise such aspects of the approach.

2. Central Concepts

This Section introduces the central concepts involved in the conceptualisation of Thought Systems presented in *Thinking Together*, [Burke 2000]. It provides:

- an overview of the inter-relationships of the concepts;
- succinct working "definitions" of the concepts expressed, wherever possible, in plain English.

For the sake of brevity, explanations of the concepts have not been included in this summary paper; *Thinking Together* does, however, explain and discuss the concepts and their inter-relationships.

Note that some of the definitions are recursive in nature. That is, they define concepts in terms of simpler versions of those concepts. Recursive definitions are sometimes misleadingly thought of as being circular. The following way of thinking may be more helpful: a recursive definition is not circular but <u>spiral</u>; rather than defining a concept in terms of itself, it defines the concept in terms of simpler versions of itself.

[6] In his book *The Quark and the Jaguar: Adventures in the Simple and the Complex*, [Gell-Mann 1994], the Nobel Laureate, Murray Gell-Mann, argues for "the need to overcome the idea, so prevalent in both academic and bureaucratic circles, that the only work worth taking seriously is highly detailed research in a specialty. We need to celebrate the equally vital contribution of those who dare to take what I call "a crude look at the whole." "

2.1 Overview

Figures 1 and 2 and Table 1 provide an architectural overview of the inter-relationships of the concepts. They describe the concepts from three different perspectives thus providing a Synoptic View, a Structural View and a Piecewise View[7] Appendix A defines and explains these Views.

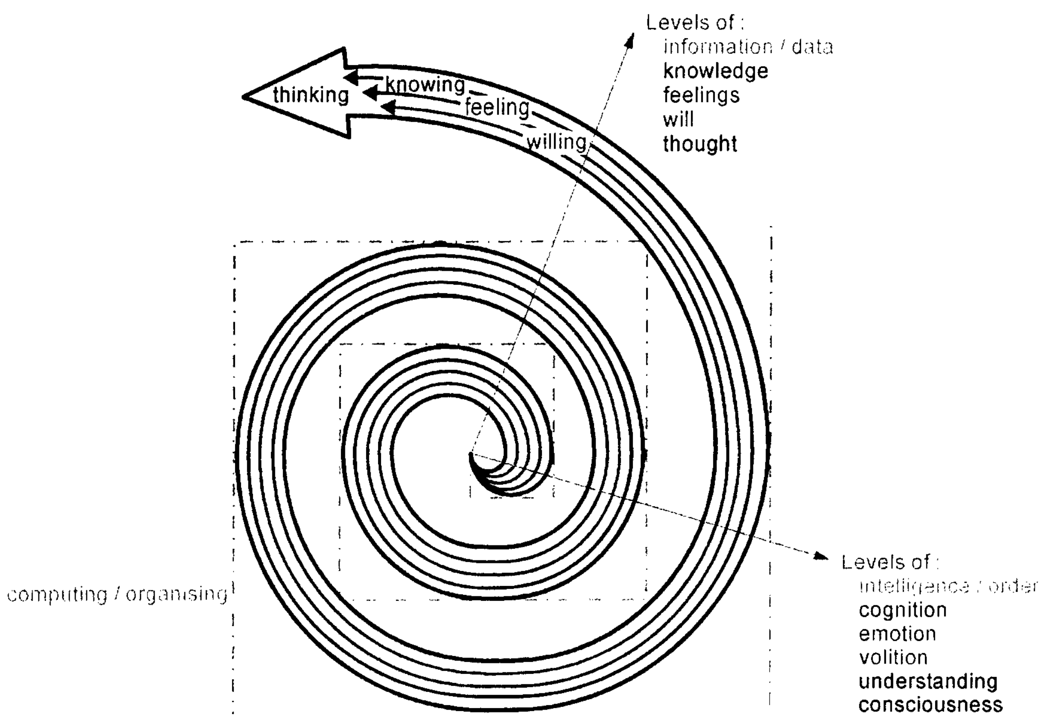

Figure 1 Thought Systems: a Synoptic View

[7] This is in keeping with Kline's hypothesis, [Kline 1995], that at least three views are needed for a reasonably good understanding of hierarchically structured systems with interfaces of mutual constraint: synoptic, piecewise and structural.

A **system** is a **complex whole.**

The **architecture** of a system is what **we understand** about that **system.**

Data are **symbols** to which meaning has not been assigned.
A **Data System** deals with **data** by **organising.**
Order is the faculty of **organising;** it is an emergent property of a **Data System.**

Information is **symbols** to which **meaning** has been assigned.
An **Information System** deals with **information** by computing.
Intelligence is the faculty of **computing;** it is an emergent property of an **Information System.**

Knowledge is **meaning** derived from **information** and other **knowledge.**
A **Knowledge System** deals with **knowledge** by **knowing.**
Cognition is the faculty of **knowing;** it is an emergent property of a **Knowledge System.**

Feelings are **meaning** derived from **information** and other **feelings.**
A **Feeling System** deals with **feelings** by **feeling.**
Emotion is the faculty of **feeling;** it is an emergent property of a **Feeling System.**

Will is **meaning** derived from **information** and other **will.**
A **Will System** deals with **will** by **willing.**
Volition is the faculty of **willing;** it is an emergent property of a **Will System.**

Thought is **meaning** derived from **knowledge, will, feelings** and other **thoughts.**
A **Thought System** deals with **thoughts** by **thinking.**
Consciousness is the faculty of **thinking;** it is an emergent property of a **Thought System.**
Understanding is **assimilated thought;** it is an emergent property of a **Thought System.**

A **Culture** is the means by which a **group of Thought Systems** attempts to **share meaning.**

Figure 2 Thought Systems: a Structural View

System Type	Input Types	Output Type	Process	Emergent Properties
Data System	Data	Data	Organising: symbol processing	Order
Information System	Data; Information	Information	Computing: sign processing	Intelligence
Knowledge System	Data; Information; Knowledge	Knowledge	Knowing: schema processing	Cognition
Will System	Data; Information; Will	Will	Willing: schema processing	Volition
Feeling System	Data; Information; Feelings	Feelings	Feeling: schema processing	Emotion
Thought System	Data; Information; Knowledge; Will; Feelings; Thought	Thought	Thinking: schema processing	Consciousness Understanding

Table 1 Thought Systems: a Piecewise View

2.2 Definitions and Explanations

Definitions of the main concepts involved in the paper are provided below; they are deliberately succinct and, wherever possible, couched in colloquial language.

2.2.1 Meaning

Meaning is what is meant; it is the significance of thoughts, signs or actions in the context of the paradigms, cultures and environments in which they are generated, interpreted and used[8].

2.2.2 Symbol

A symbol is an entity that could be, but has not been, used to represent[9] meaning.

2.2.3 Sign

A sign is an entity used to represent meaning.

2.2.4 Schema

A schema is a conception[10] of what is common to the members of a set[11]; it is a mental sign.

2.2.5 Schema Description

A schema description is a physical representation of a schema; it is a physical sign.

2.2.6 System

A system is a complex whole; an integrated entity of heterogeneous components that acts in a coordinated way.[12]

Figure 3, which is derived from [Flood and Jackson 1991], attempts to summarise the general conception of "system"[13].

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[8] See Edgar and Sedgwick, [Edgar and Sedgwick 1999], for a brief summary of the academic discourse concerning the nature of meaning. Also see Hall, [Hall 1997], Ayer, [Ayer 1967 (1946)], de Saussure, [Saussure 1983 (1916)], Kuhn, [Kuhn 1996 (1962)], the *early* Wittgenstein, [Wittgenstein 1961 (1921)], the *later* Wittgenstein, [Wittgenstein 1967 (1953)], Barthes, [Barthes 1964], Derrida, [Derrida 1978 (1967)], Foucault, [Foucault 1980],etc.

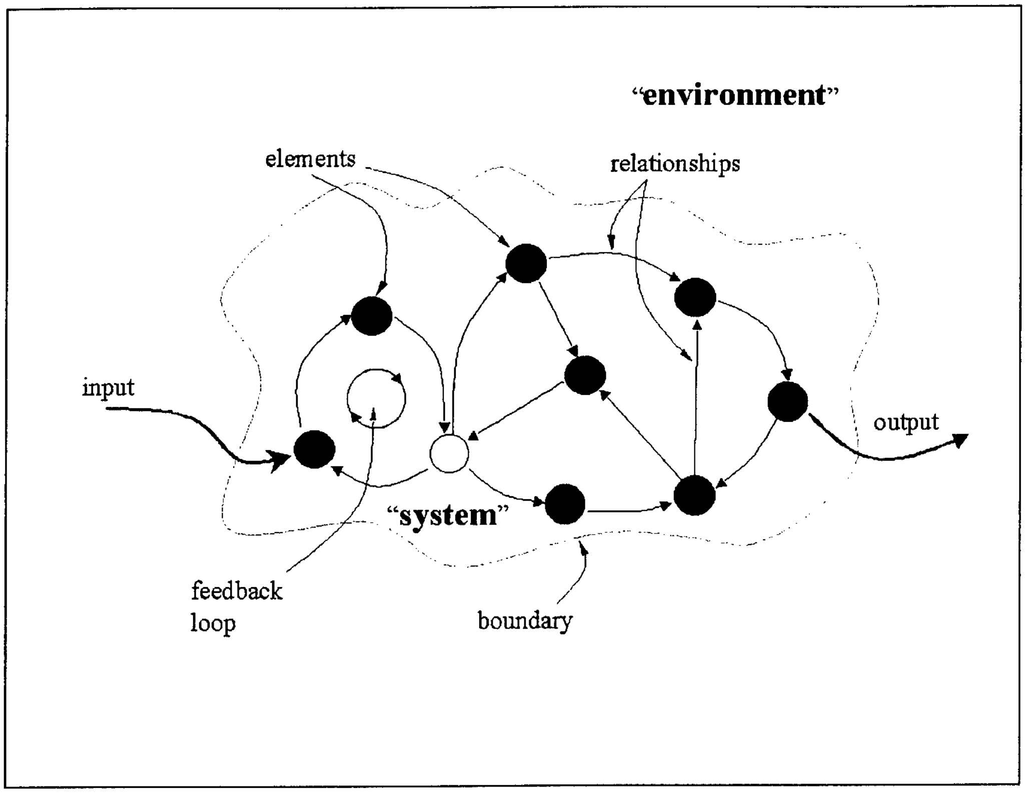
[9] See Hall, [Hall 1997], for a discussion of the concept of representation.

[10] In this work, the noun "conception", is used to refer to "that which has been formed in the mind".

[11] In this work, the term "set" is used to refer to "any well-defined list or collection of objects".

[12] Multiple conceptions exist for the notion of system. Burke, [Burke 2000], addresses the diversity of these different ways of thinking; a review is made of the variety of definitions that have been made for the system concept; examples are provided from a selection of disciplines considered relevant in the Defence context. The suggestion is made that these different ways of thinking profoundly effect the practices and behaviour of their proponents when acting as individuals and as groups; an example from the Systems Engineering discipline is discussed.

[13] Appendix I of *Thinking Together*, [Burke 2000], provides brief definitions and explanations of the main concepts relating to Systems of Systems, Joint Systems etc.



Central concepts	**Other concepts**
element (or component)	attributes
relationship	transformation
boundary	purpose
input	open system
output	homeostasis
environment	emergence
feedback	communication
	control
	identity
	hierarchy

Figure 3 *The General Conception of System, from Flood and Jackson,* [Flood and Jackson 1991]

2.2.7 Complexity

The complexity of a system, relative to an observer, is the length of the schema used by the observer to describe the system.[14]

2.2.8 Emergent Properties

An emergent property[15] of a system is a property that is meaningful when attributed to the whole system, not to its components.

[14] See Gell-Mann, [Gell-Mann 1994], for a discussion of this concept.

2.2.9 Systems Hierarchy

A system, created by integrating components into a complex whole, can be thought of as a multi-levelled structure of systems within systems. Each system in the structure is a whole with respect to its component parts and can also be a component of a system at a higher level in the structure. The various emergent properties of the composite system and its components characterise different levels of complexity in the composite system's structure.

A systems hierarchy is an architecture view[16] of a system from a structural perspective made on the basis of the existence of emergent properties.

Each level in a systems hierarchy is characterised by emergent properties that do not exist at other levels; higher levels in the systems hierarchy are not necessarily more complex than lower levels. It is emphasised that a systems hierarchy is not a hierarchy of the levels of complexity of a system; it is an architecture view of a system from the perspective of emergence not from the perspective of level of complexity.

It is also emphasised the systems hierarchy concept is not the same as the concept of the hierarchy of systems' complexity first proposed by Boulding, [Boulding 1956; Boulding 1956] and later professed by Checkland, [Checkland 1981]. Whereas a systems hierarchy discerns the different levels of emergence apparent in a single system, a hierarchy of systems' complexity categorises commonly occurring systems into broad classes on the basis of their (highest) levels of complexity[17].

2.2.10 Architecture[18]

The Architecture of a system is the collective understanding[19] of a system of the community involved with that system.

2.2.11 Architecture Description

An Architecture Description is a representation of aspects of understanding about a system.

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[15] According to Capra, [Capra 1996], the term "emergent properties" was coined by the philosopher C. D. Broad, [Broad 1923], to refer to those system properties that emerge at a certain level of complexity (or hierarchy) but do not exist at lower levels.
[16] The concept of "architecture view" is defined in Section 2.2.11.
[17] Kline, [Kline 1995], proposes another hierarchy of systems' complexity based on the notion of a "complexity index" which he also defines and explains.
[18] The definitions of concepts relating to architecture are based on those from *Understanding Architecture*, [Burke 2000], which provides a fuller explanation of these concepts and gives various examples. It should be noted that the conception of architecture expressed in the April 2000 draft of *Understanding Architecture* is knowledge-based rather than thought-based. It defines the architecture of a system as "the collective knowledge about that system of the architecture community involved with that system"; it does not explicitly consider the feelings and wills of the community in regard of the system. It may be appropriate to revise this thinking in future versions.
[19] The concept of "understanding" is defined in Section 2.2.30.

2.2.12 Architecture View

Architecture Views are classes of architecture descriptions that allow understanding about systems to be represented from particular perspectives.

2.2.13 Data[20]

Data is a set of symbols; it is a set of entities that could be, but have not been, used to represent meaning.

2.2.14 Data System

A Data System is an entity capable of symbol processing; it deals with data.

2.2.15 Order

Order is the faculty of organising; it is an emergent property of a Data System resulting from the interaction of its organising processes.

For a given observer and given inputs, the level of order of a Data System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between organising and order in a Data System: order enables organising processes; interacting organising processes create (higher level) order; (higher level) order enables (higher level) organising processes, etc. Accordingly, the systems hierarchy of a Data System is characterised by the levels of order of the successive "unfoldings"[21] of this recursive relationship.

2.2.16 Information

Information is a set of signs; it is a set of entities used to represent meaning.

2.2.17 Information System

An Information System is an entity capable of sign processing; it deals with data and information.

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[20] Confusion is common regarding the meanings of the terms "data", "information", and "knowledge". Different authors use them in different ways. Accordingly, some readers may find it helpful to consider Appendix A of *Understanding Architecture, [Burke 2000]*, that presents ways in which the terms are used in contemporary discourse. It also discusses how a coherent understanding of the concepts they refer to can be developed and attempts to isolate distinguishing features of the concepts. This way of thinking has been used as the basis of the definitions and explanations presented here.

[21] Note that according to Gell-Mann, [Gell-Mann 1994], the words "simplicity" and "complexity" have common etymological roots. "Simplicity" is derived from an expression meaning "once folded"; "complexity" from an expression meaning "braided together". Hence it is suggested that the use of the term "unfoldings" in the context of recursive relationships is appropriate from both a linguistic and metaphoric point of view.

2.2.18 Intelligence

Intelligence is the faculty of computing; it is an emergent property of an Information System resulting from the interaction of its computing processes.

There is an inherently recursive relationship between computing and intelligence in an Information System: intelligence enables computing processes; interacting computing processes create (higher level) intelligence; (higher level) intelligence enables (higher level) computing processes, etc. Accordingly, the systems hierarchy of an Information System is characterised by the levels of intelligence of the successive "unfoldings" of this recursive relationship.

2.2.19 Knowledge

Knowledge is meaning derived from information and other knowledge.

Knowing is the process by which meaning is derived from information and other knowledge[22]. Knowing occurs by processing schemata relating to cultural, theoretical and practical matters[23].

Table 2 gives some examples of specific processes of knowing.

[22] It is emphasised that knowing is not necessarily a rational process. It is not synonymous with reasoning; neither is it restricted to propositions to which truth-values can be assigned. See Edgar and Sedgwick, [Edgar and Sedgwick 1999], for a brief summary of the academic discourse concerning the nature of rationality. Also see Descartes, [Descartes 1986 (1637 and 1641)], Hume, [Hume 1990 (1739)], Kant, [Kant 1964 (1781)], Nietzsche, [Nietzsche 1986 (1878 - 80)], etc.

[23] Note the parallels between this conception of knowing and that of socio-epistemo-technical systems.

perceiving	conceiving	reasoning	learning
representing	experimenting	analysing	synthesising
creating	guessing	speculating	intuiting
assimilating	integrating	fusing	combining
associating	disassociating	matching	recognising
observing	measuring	interpreting	construing
appreciating	considering	appraising	judging
criticising	idealising	researching	exploring
investigating	believing	approximating	visualising
imagining	conceptualising	theorising	modelling
categorising	generalising	abstracting	comprehendi ng
proving	disproving	explaining	deciding
innovating	devising	designing	describing
expressing	depicting	anticipating	predicting
organising	structuring	regulating	planning
improvising	adapting	compensating	confusing

Table 2 Examples of specific processes of knowing.

2.2.20 Knowledge System

A Knowledge System is an entity capable of knowing; it deals with data, information and knowledge.

Knowledge exists only in Knowledge Systems; it is what a Knowledge System knows.

Various types of Knowledge Systems are possible:

- A *Natural Knowledge System* is a Knowledge System that has been synthesised by some natural process or processes.
- A *Non-Natural Knowledge System* is a Knowledge System that has been synthesised by some non-natural process or processes.
- A *Hybrid Knowledge System* is a Knowledge System that has been synthesised by a combination of natural and non-natural processes.
- An *Artificial Knowledge System* is either a Non-Natural Knowledge System or a Hybrid Knowledge System.

2.2.21 Cognition

Cognition is the faculty of knowing; it is an emergent property of a Knowledge System resulting from the interaction of its knowing processes.

For a given observer and given inputs, the level of cognition of a Knowledge System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between knowing and cognition in a Knowledge System: cognition enables knowing processes; interacting knowing processes create (higher level) cognition; (higher level) cognition enables (higher level) knowing processes, etc. Accordingly, the systems hierarchy of a Knowledge System is characterised by the levels of cognition of the successive "unfoldings" of this recursive relationship.

Cognition is distinguished from both emotion and volition, which are considered as emergent properties of Feeling Systems and Will Systems respectively.

Perception, conception and reasoning are important classes of cognition.

2.2.22 Feelings

Feelings are meaning derived from information and other feelings.

Feeling is the process by which meaning is derived from information and other feelings. Feeling occurs by processing schemata relating to instinctive sensibilities.

Table 3 gives some specific examples of feelings.

joy	fear	loneliness	meaninglessness
love	hate	envy	ecstasy
anger	lust	panic	worry
righteousness	invasion	injustice	agitation
disappointment	let down	harassment	outrage
abhorrence	dismay	boredom	satisfaction
appreciation	rejection	fulfilment	being ignored
being criticised	irritation	helplessness	optimism
pessimism	belonging	identity	peacefulness
calm	anguish	grief	unfairness
abandon	abandonment	being praised	rushed
"rush"	rejection	being soothed	being blessed
relief	justification	giving forgiveness	being forgiven
damned	doubt	expectation	anticipation
release	contentment	superiority	inferiority
relaxation	distress	being unloved	safety
being used	pity	despair	

Table 3 Examples of feelings.

2.2.23 Feeling System

A Feeling System is an entity capable of feeling; it deals with data, information and feelings.

Feelings exist only in Feeling Systems; it is what a Feeling System feels.

Feelings result from the activity of a Feeling System in deriving meaning from information and other feelings. The quality of feelings depends upon both the capacity of the Feeling System to derive meaning and the data, information and feelings accessible to the entity.

Various types of Feeling Systems are conceivable but not necessarily possible:

- A *Natural Feeling System* is a Feeling System that has been synthesised by some natural process or processes.
- A *Non-Natural Feeling System* is a Feeling System that has been synthesised by some non-natural process or processes.
- A *Hybrid Feeling System* is a Feeling System that has been synthesised by a combination of natural and non-natural processes.
- An *Artificial Feeling System* is either a Non-Natural Feeling System or a Hybrid Feeling System.

2.2.24 Emotion

Emotion is the faculty of feeling; it is an emergent property of a Feeling System resulting from the interaction of its feeling processes.

For a given observer and given inputs, the level of emotion of a Feeling System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between feeling and emotion in a Feeling System: emotion enables feeling processes; interacting feeling processes create (higher level) emotion; (higher level) emotion enables (higher level) feeling processes, etc. Accordingly, the systems hierarchy of a Feeling System is characterised by the levels of emotion of the successive "unfoldings" of this recursive relationship.

2.2.25 Will

Will is meaning derived from information and other will.

Willing is the process by which meaning is derived from information and other will. Willing occurs by processing schemata relating to the determination to effect specific activities or outcomes.

Table 4 gives some specific examples of will.

to live	to reproduce	to win	to succeed
to own	to belong	to have power	to be responsible
to be respected	to contribute	to influence	to change
to glorify God	to go to Heaven	to achieve Enlightenment	to reduce suffering
to be virtuous	to be famous	to be appreciated	to be remembered
to protect	to defend	to pacify	to appease
to pursue justice	to further a cause	to avenge	to recover
to kill	to maim	to mutilate	to destroy
to persecute	to deny	to defy	to desecrate
to deceive	to rectify	to discover	to research
to understand	to learn	to create	to express
to build	to grow	to be free	to escape
to take risks	to avoid risks	to be autonomous	to be secure
to be beautiful	to be healthy	to be happy	to communicate
to be loved	to have an easy life	to cause no harm	to cure
to nurture			

Table 4 Examples of will

2.2.26 Will System

A Will System is an entity capable of willing; it deals with data, information and will.

Will exists only in Will Systems; it is what a Will System wills.

Various types of Will Systems are conceivable but not necessarily possible:

- A <u>*Natural Will System*</u> is a Will System that has been synthesised by some natural process or processes.
- A <u>*Non-Natural Will System*</u> is a Will System that has been synthesised by some non-natural process or processes.
- A <u>*Hybrid Will System*</u> is a Will System that has been synthesised by a combination of natural and non-natural processes.
- An <u>*Artificial Will System*</u> is either a Non-Natural Will System or a Hybrid Will System.

2.2.27 Volition

Volition is the faculty of willing; it is an emergent property of a Will System resulting from the interaction of its willing processes.

For a given observer and given inputs, the level of volition of a Will System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between willing and volition in a Will System: volition enables willing processes; interacting willing processes create (higher level) volition; (higher level) volition enables (higher level) willing processes, etc. Accordingly, the systems hierarchy of a Will System is characterised by the levels of volition of the successive "unfoldings" of this recursive relationship.

2.2.28 Thought

Thought is meaning derived from knowledge, will, feelings and other thoughts; it is a state of mind[24].

Thinking is the process by which meaning is derived from knowledge, will, feelings and other thoughts.

Thoughts are outputs of Thought Systems; they result from the interaction of a Thought System's Knowledge System, Will System and Feeling System components.

Wills, feelings and knowledge are classes of thoughts resulting from the independent action of a Thought System's Knowledge System, Will System and Feeling System components respectively.

Values and beliefs are classes of thoughts. Values and beliefs can strongly influence subsequent thoughts[25].

Decisions are a class of thoughts usually resulting from the dependent interaction of a Thought System's Knowledge System, Will System and Feeling System components.

Intentions are decisions to act. Therefore, intentions are a class of thoughts.

2.2.29 Thought System

A Thought System is an entity capable of thinking; it deals with data, information, knowledge, will and feelings.

Thought exists only in Thought Systems; it is what a Thought System thinks.

A Thought System has at least one component that is either a Knowledge System or Feeling System or Will System; it may also have components that are Information Systems and/or Data Systems.

A composite Thought System has more than one component. In the extreme and atypical case, a Thought System can comprise just an isolated Knowledge System, Feeling System or Will System.

Examples of Thought Systems include:

- individual human minds;
- insect colonies;
- the Knowledge Systems Building, DSTO, Salisbury;
- Headquarters Australian Theatre (HQAST);
- Australian Defence Headquarters (ADHQ).

Various other examples of existing and conjectured Thought Systems are discussed in *Thinking Together.*

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[24] In this work, the term "mind" is used in the following sense: "Mind is the seat of cognition, emotion, volition and consciousness, it is that which knows, feels, wills and thinks."
[25] See Boulding, [Boulding 1956], for a discussion of this relationship.

2.2.30 Consciousness

Consciousness is the faculty of thinking; it is an emergent property of a Thought System resulting from the interaction of its thinking processes.

For a given observer and given inputs, the level of consciousness of a Thought System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between thinking and consciousness in a Thought System: consciousness enables thinking processes; interacting thinking processes create (higher level) consciousness; (higher level) consciousness enables (higher level) thinking processes, etc. Accordingly, the systems hierarchy of a Thought System is characterised by the levels of consciousness of the successive "unfoldings" of this recursive relationship.

Cognition, volition and emotion are all modes of consciousness; they can occur independently or in interaction. The independent modes are special cases and do not occur frequently in naturally synthesised Thought Systems.

2.2.31 Understanding

Understanding is assimilated thought; it is an emergent property of a Thought System resulting from the integration of its thoughts.

For a given observer and given inputs, the level of understanding of a Thought System is the complexity of the system's outputs. Accordingly, each level in the systems hierarchy of a Thought System is characterised by a level of understanding as well as a level of consciousness.

2.2.32 Culture

A culture is the (system of) processes and practices by which a group of Thought Systems attempts to share thoughts, ie to share meaning.

Thought Systems that share the same culture use information to express themselves in ways that are likely to be understood consistently by each other and interpret information in roughly the same ways. Culture influences the behaviour of individual Thought Systems; it can also organise and regulate the dependent and inter-dependent behaviour of the members of a group of Thought Systems.

2.2.33 Culture System

A Culture System is a System of Thought Systems[26] that attempts to share thoughts, i.e. to share meaning, by operating within one or more shared cultures.

Note that a Culture System is itself a Thought System; as a System of Thought Systems, i.e. a system whose components are Thought Systems, a Culture System is necessarily a Thought System.

[26] Appendix D provides brief definitions and explanations of the main concepts relating to Systems of Systems.

3. Examples

Section 3 outlines two examples intended to indicate how the conceptualisation presented in Section 2 might be extended and applied to the domain of TWAW.

Figure 4 is a synoptic view of a Culture System comprising two similar Thought Systems operating within similar but different cultures. This may be representative, for example, of two single services operating jointly or two national Defence forces operating in coalition. Considerable interaction occurs between the Thinking Systems' processes which gives rise to various emergent properties including:

- collective and shared consciousness;
- collective and shared understanding[27].

Figure 4 suggests that, in the specific case that it depicts, some commonality exists between the Thought System components and that the Culture System is reasonably coherent. Although there are circumstances in which this would be an acceptable situation in TWAW, it is a situation that ideally should be improved.

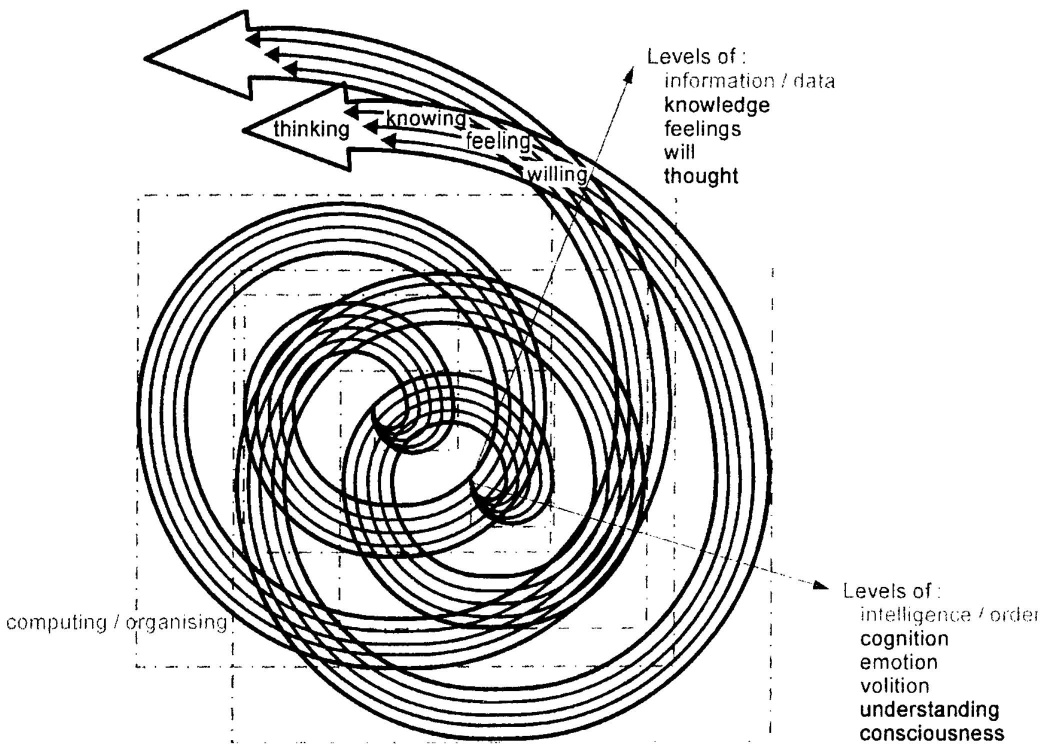

Figure 4 *Culture Systems: A Synoptic View of a Culture System with two similar Thought Systems components operating within similar cultures.*

Figure 5 is a synoptic view of a Culture System comprising two different Thought Systems - one dominates the other - operating within different cultures. This may be representative, for example, of two potentially adversarial Defence forces interacting to

[27] See *Understanding Architecture*, Section 4, [Burke 2000], for a discussion of the distinction between the terms "collective", "shared" and "common".

avoid conflict and maintain peace. Considerable interaction between the Thinking Systems' processes which gives rise to various emergent properties including:

- collective and shared consciousness;
- collective and shared understanding.

Figure 5 suggests that, in the specific case that it depicts, despite the lack of commonality between the Thought System components, considerable coherence is achieved in the Culture System. There are circumstances in which this would be a highly desirable situation in TWAW, particularly in Thought Anti-War.

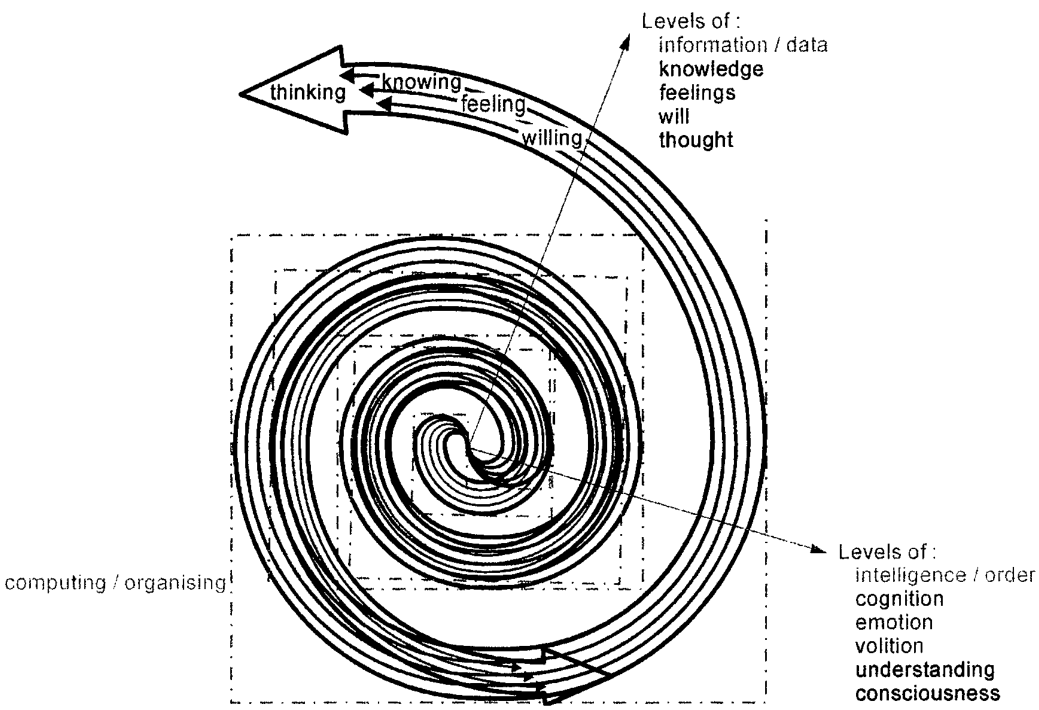

Figure 5 *Culture Systems: A Synoptic View of a Culture System with two dissimilar Thought Systems components operating within dissimilar cultures.*

4. Discussion and Conclusions

4.1 Overview

Section 1 introduced the notions of Thought Systems and Thought Warfare and Anti-Warfare (TWAW). It suggested that TWAW is a "bigger" concept than that of Network Centric Warfare (NCW). It indicated that the scope of NCW can be considered to be, broadly speaking, the same as what the Tofflers' mean by the term "Knowledge Warfare" in that it involves the interaction of groups of people acting as knowledge agents supported by networks of information and data systems. However, unlike TWAW, NCW does not explicitly address the emotional and volitional aspects of such interactions. Furthermore, it does not explicitly consider issues relating to "Anti-Warfare".

Section 2 summarised the conceptualisation[28] of the domain of Thought Systems developed in *Thinking Together*, [Burke 2000]. As such, it represents the core of a conceptualisation of the domain of TWAW that is the primary research focus. The conceptualisation has been produced as a result of an exercise in Architecture Thinking[29] in which architecture is considered to be what a community understands about a system.

Section 3 indicated how the core conceptualisation might be elaborated and applied to TWAW.

4.2 Features of the Thought Systems Conceptualisation

There is an inherent plurality in the domain of thought[30] of TWAW. It follows, therefore, that no monistic conception will be able to accommodate all of its aspects. Different conceptions can, however, be useful for different specific purposes. The core conceptualisation has been developed for a specific purpose: to afford a readily grasped, coherent understanding of the central concepts of the domain of TWAW that distinguishes the salient features of the inter-relationships of the concepts in order to support cogent discourse regarding TWAW. Three points are emphasised in this respect:

- The core conceptualisation does not attempt to be exhaustive, i.e. it does not aim to give complete coverage of the domain that it addresses. For example, there may be processes by which meaning can be derived other than knowing, feeling, willing and thinking;
- Not all of the concepts involved in the core conceptualisation are defined. As in all such theoretical work, some concepts are treated as being axiomatic, i.e. they are regarded as being self-evident and thus do not require definition. Important examples include representation, faculty, etc. Furthermore, some of the concepts involved are introduced by suggestion rather than by being fully

[28] In this work, the term "conceptualisation" is used to refer to "a system of ideas".
[29] See *Understanding Architecture*, [Burke 2000], for an exposition of this new field.
[30] See *Understanding Architecture*, Appendix C, [Burke 2000], for definitions of the terms "pluralism" and "monism" and an introduction to Sir Isaiah Berlin's views on the importance of pluralism in human affairs. See Berlin, [Berlin 1979; Berlin 1990], for a fuller exposition of these ideas.

articulated in well-formed definitions[31]. The most important examples of these are knowing, feeling and willing;

- Although the core conceptualisation is not (richly) pluralistic, this should not be taken as implying that it is monistic. Although the core conceptualisation provides just a single view of its domain, it does not purport to be the only view that is valid or relevant.

The major features of the core conceptualisation are:

- Meaning is arguably the single most important issue in the domain; the conceptualisation is dominated by what is involved in assigning, deriving and sharing meaning by Information Systems, Knowledge Systems, Thought Systems, etc;
- Recursive relationships of intelligence/computing, cognition/knowing, consciousness/thinking, etc give rise to hierarchies of levels of complexity in Information Systems, Knowledge Systems, Thought Systems, etc;
- Some of the concepts are extensively inter-related. For example, consider how the concept of schema is inter-woven through the conceptualisation:
    - a schema is what is understood to be common to the members of a set;
    - schema processing is the essence of thinking; it is how meaning is derived from information;
    - schema is a central concept in complexity; it is used to describe a system's regularities;
    - complexity is a central concept in system; it characterises the system's emergent properties;
    - systems hierarchy is an architecture view of a system; it highlights the different levels of complexity in a system;
    - architecture is what we understand about a system, i.e. it is the meaning derived from a system through thinking/schema processing.

It is emphasised that the conceptualisation does not commit to a "mind as machine" metaphor in which cognition and thought are considered to be merely information processing activities. It adopts a radically different stance: it assumes that "meaning matters".

4.3 Insights for NCW

The core conceptualisation affords various new insights that are of significance to the Network Centric Warfare community. Some of these are summarised below.

4.3.1 Inter-relating Concepts

The core conceptualisation exposes the natures of various concepts (and their inter-relationships) that are of crucial importance in NCW. These include:

- system;
- architecture;
- culture/Culture System;

[31] In *A Short History of Chinese Philosophy*, [Yu-Lan 1948], Fung Yu-Lan describes how "suggestiveness, not articulateness, is the ideal of all Chinese art." He remarks on the apparent "briefness and disconnectedness" of Chinese philosophical works and how this differs from the elaborate reasoning and detailed argument characteristic of most Occidental philosophy.

- understanding;
- meaning;
- thought/Thought System;
- knowledge/Knowledge System;
- feeling/Feeling System;
- will/Will System;
- information/Information System;
- data/Data System.

Confusion in respect of these concepts has led to some potentially dangerous misunderstandings being formed. For example, US Joint Vision 2010[32] (JV2010), [DOD 1997], suggests that "information superiority: the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same", will assure "dominant battlespace awareness". However, if it is accepted that battlespace awareness is ultimately concerned with the development of shared understanding in a group of people[33], then, in the terms of the core conceptualisation, it can only be fully understood as a Culture System issue. In considering battlespace awareness to be merely an Information System issue, JV2010 essentially overlooks the importance of the interaction of the Information Systems and the other components of Thought Systems – in particular Knowledge Systems - in the development of shared understanding[34]. Since battlespace awareness results from a Defence Culture System making sense of information rather than just collecting, processing, and disseminating information, it follows that it is erroneous to assume that dominant battlespace awareness will be assured by information superiority alone.

Interestingly, *Network Centric Warfare*, [Alberts, Garstka et al. 1999], differs from JV2010 in this respect. It regards the essence of NCW as the translation of "information superiority into combat power by effectively linking knowledgeable entities in the battlespace" and re-defines information superiority as "a state that is achieved when a competitive advantage is derived from the ability to exploit a superior information position". It is contended that this view, despite being broader than that of JV2010 in that it encompasses the interaction of "knowledgeable entities" and information, is also misleading: a competitive advantage in NCW does not necessarily require "a superior information" position if a Defence Culture System can "out think" an adversary without being better informed than it[35].

4.3.2 Coherent Thinking and Discourse

The core conceptualisation provides a coherent way of thinking, and a language to support discourse, about current military issues of relevance to the NCW community. For instance, *Thinking Together*, [Burke 2000], Section 4, discusses the following as examples of composite Thought Systems of current interest to Defence:

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[32] US Joint Vision 2010 (JV2010), [DOD 1997], is "the conceptual template for how America's Armed Forces will channel the vitality and innovation of our people and leverage technological opportunities to achieve new levels of effectiveness in joint warfighting."
[33] RADM Briggs, has recently defined situational awareness in terms of "shared understanding", [Briggs 1998]. At that time, RADM Briggs held the position of Head, Strategic Command Division in Australian Defence Headquarters.
[34] *Thinking Together*, [Burke 2000], expands upon this. In particular, see Section 4.2.2 and Appendices F and G.
[35] *Information Superiority, Network Centric Warfare and the Knowledge Edge,[Burke 2000],* elaborates upon this.

- C4ISREW Systems;
- Situational Awareness;
- Communication of Intent;
- Systems of Systems;
- Way of Warfighting, [Defence 1998].
- Collective Intelligence, [Levy 1997];
- *Ba*, [Nonaka and Konno 1998 (Spring)].

Discussion of this sort provides insight into the prevailing architectural characteristics of current Thought Systems in terms of the typical characteristics and inter-relationships of their Data Systems, Information Systems, Knowledge Systems, Will Systems and Feeling Systems components. It also helps us to appreciate that the collaboration of groups of people on thought-based tasks is currently extremely communication intensive and is usually both ineffective and inefficient. This leads to the realisation that reliance on information sharing is arguably the cause of the most significant deficiencies of current Thought Systems.

4.3.3 Future Conflict and New Forms of Thought Systems

The core conceptualisation promotes speculation about the nature of future military conflict and its avoidance related to NCW. In particular, it promotes speculation about new forms of Thought System that may provide significant comparative advantage in this respect[36]. It is planned to publish extensively on these matters in due course.

5. Acknowledgements

Various people from the nascent Thought Systems community have made contributions to this work. Although there are too many to list explicitly in a paper of this sort, each of them is appreciated and is acknowledged with gratitude.

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Appendix A: Architecture Views

Architecture Views are classes of architecture descriptions that allow knowledge about systems to be represented from particular perspectives.

A.1 Structural View

Arguably, the most common type of architecture view is the structural view[37] in which a system is depicted as a set of inter-related elements.[38] [39] Examples include:

- the contents lists of books and papers;
- the taxonomies used by biologists to categorise forms of life;
- the high-level designs of software systems;
- the schematic diagrams used by chemists and physicists to depict the configuration of atoms in crystals, molecules, polymers, etc;
- the graphs used by mathematicians to depict systems as networks of nodes and inter-connecting arcs;
- the blue-prints used by the architects of buildings and engineers in general;
- the master-plans used by military and business strategists to depict the inter-relationships of other subsidiary plans;
- the organisation charts used to depict the authority/responsibility structures in institutions;
- the family-trees used to depict the genealogy of family groups;
- the route-planners provided in road-atlases to depict the various major routes between towns, cities etc.

A.2 Piecewise View

Another common architecture view is the piecewise view that depicts the smallest relevant parts of a system for a particular problem. Examples include:

- the detailed wiring diagrams produced by electronic and electrical engineers that show the smallest components of the devices with which they are concerned and the way that they are inter-connected;
- the detailed design drawings produced by mechanical engineers that show the smallest components of the devices with which they are concerned and the way that they are inter-connected;
- the musical scores used by composers to depict the notes to be played by the instruments in orchestras;
- the ingredients lists of recipes;
- the inventories of repositories.

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[37] Kline, [Kline 1995], uses the term "structural view" to denote a description of how the components of a system "go together" for all levels of its (hierarchical) structure.

[38] IEEE Std 610.12-1990 defines the concept of architecture as follows:
architecture. The organisational structure of a system or component. *See also:* **component; module; subprogram; routine.**

[39] See Section 4.5 of *Understanding Architecture* for a discussion of the consequences to the Systems Thinking community of this definition.

A.3 Synoptic View

A less common type of architecture view is the synoptic view[40]. Synoptic views treat systems as atomic entities or wholes. They selectively emphasise characteristics of the system that are deemed to be salient in a given context and suppress (or omit) information that is not pertinent in these respects. [41] Examples include:

- the synoptic weather charts used in television and newspaper weather reports. These are perhaps the examples of synoptic views that are most commonly encountered in everyday life;
- "black-box" system diagrams that emphasise the inputs and outputs to a system (the black-box) and the relationships between the inputs and outputs resulting from the action of that system. Such diagrams do not depict how the transformation from input to output takes place;
- topographical, political, climatic, demographic etc. maps;
- the High Level Operations Concept Graphics used in the C4ISR Architecture Framework[42].

A.4 Panoptic View

The panoptic view is an important but uncommon architecture view. A panoptic view of a system depicts all aspects of that system at once. In most cases, practical considerations necessitate that panoptic views only include information about systems above a given scale of resolution. An appreciation of the difference between the synoptic and panoptic views is afforded by considering the simple example discussed in Section 4.7 of *Understanding Architecture.*

Architecture descriptions that depict temporal aspects of knowledge about a system are rare.[43] The usual situation is that an architecture description depicts aspects of knowledge about a system as it exists, or is intended to be, at a single point in time. Such architecture descriptions do not capture how a system operates or changes over

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[40] Kline, [Kline 1995], uses the term "synoptic view" to denote a synthetic overview of a system that:

(a) defines system boundaries;
(b) defines what can go in and out of a system and other possible interactions between the system and the environment;
(c) states system goals, if there are any.

[41] See Section 4.2 of *Understanding Architecture* .

[42] See Section 4.4 of *Understanding Architecture* .

[43] Again, modern television weather reports that use animated synoptic charts to illustrate the development of weather patterns over periods of time perhaps provide the examples that are most commonly encountered in everyday life.

time. They are analogous to "snapshots" taken with a camera using a polarised filter. They are partial images of an object produced by selectively recording part of what is known about that object at a particular instant. [44]

Architecture views selectively emphasise different types of characteristics of knowledge about systems. However, redundancy can exist between different architecture views if their perspectives overlap [45]. Architecture views are said to be orthogonal if their perspectives do not overlap in which case there is no redundancy in the knowledge about systems that they represent.

[44] See the discussion of The London Underground in Section 4.2 of *Understanding Architecture*.
[45] The C4ISR Architecture Framework discussed in Section 4.4 of *Understanding Architecture* provides an example of this.

Thought Systems and Network Centric Warfare

Martin Burke
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19. ABSTRACT

The notion of Thought Warfare and Anti-Warfare (TWAW) has been introduced in earlier work as a way of thinking about future military conflict and its avoidance. TWAW involves the dynamic interaction of allies' and adversaries' Thought Systems. Current Thought Systems involve entities capable of cognition, emotion and volition - typically (groups of) people - interacting via networks of information and data systems.

This paper summarises a conceptualisation, ie a system of ideas, of the domain of Thought Systems. The relationship between TWAW and Network Centric Warfare (NCW) is explained: TWAW encompasses NCW. Unlike NCW, TWAW explicitly considers the interaction of will and feelings as well as knowledge, information and data in networked systems of people and machines in both the conduct of war and in the maintenance of peace. This affords various new insights that may be of significance to the NCW community.

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